Coupled WRF | WRF-Hydro V5 Test Case User Guide

Creation Date: 26 October 2018
WRF-Hydro Development Team

Purpose

This test case for the coupled WRF | WRF-Hydro modeling system is meant to orient you to running the modeling system using prepared geographical inputs for WRF-Hydro and sample initial and boundary conditions for WRF. Note that some of the initial and boundary conditions for this test case have been modified in order to produce a hydrologic response over a very limited spatial domain. Results generated from this test case should not be interpreted as a real simulation and users should consult the WRF and WPS documentation for best practices with respect to domain and model configuration. The purpose of this test case is to provide baseline instructions and a computationally tractable test case for users to familiarize themselves with the modeling system and help ensure the modeling system is running properly on their systems. Please see the README.txt file provided with the test case for a more detailed description of the contents.

For a detailed technical description of WRF-Hydro and instructions on how to run WRF | WRF-Hydro in coupled mode see the *WRF-Hydro V5 Technical Description* document and *How to Run WRF-Hydro V5 in Coupled Mode* user guide available from https://ral.ucar.edu/projects/wrf_hydro.

For further information regarding the WRF model and the WRF Preprocessing System (WPS) see the WRF Users' Guide located here:
http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_v4/contents.html

For additional information regarding the WRF-Hydro modeling system and possible training opportunities, please visit:
https://ral.ucar.edu/projects/wrf_hydro

Requirements

Linux operating system (for the cross-platform containerized version of this tutorial see here: https://hub.docker.com/r/wrfhydro/coupled_training/)

- WRF-Hydro source code > v5.0.x
  https://ral.ucar.edu/projects/wrf_hydro/model-code
- WRF source code > v4.0.x
  https://github.com/wrf-model/WRF/archive/v4.0.1.tar.gz
- WPS source code > v4.0.x
  https://github.com/wrf-model/WPS/archive/v4.0.1.tar.gz
- WPS geographic data
  http://www2.mmm.ucar.edu/wrf/src/wps_files/geog_high_res_mandatory.tar.gz
- An official WRF-Hydro coupled test case > v5.0.x
  https://ral.ucar.edu/projects/wrf_hydro/testcases
- All system libraries needed by the WRF-Hydro modelling system can be found in the *How To Build & Run WRF-Hydro V5 in Standalone Mode* user guide and the FAQ web page located at https://ral.ucar.edu/projects/wrf_hydro
- All system libraries needed by the WRF modeling system and WPS can be found in the *WRF User's Guide* located here:
  http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_v4/contents.html

Step by step walkthrough

Directory structure setup

We will organize all files and folders under a common top-level directory to simplify commands in this walkthrough. All paths mentioned in this walkthrough will be relative to this top-level directory. For example, /home/user/project_directory/example_case_coupled/ will be referred to as example_case_coupled/. The following steps walk you through how to setup your project directory.

1. Open a terminal window
2. Create a top-level directory that will hold all subdirectories and files used for this walkthrough. Hereafter referred to as the 'project directory'.
3. Copy the uncompressed WRF, WPS, and WRF-Hydro source codes into the project directory created in step 2.
4. Copy the uncompressed WPS geographic data into the WPS directory.
5. Copy the uncompressed coupled example case into the project directory.
6. Your project directory structure should now look like the following:

```
-project_directory
    |___wrf_hydro_nwm_public*/
        |___trunk/
            |___NDHMS/
    |___WRF*/
    |___WPS*/
        |___geogrid/
        |___metgrid/
        |___ungrib/
        |___geog/
    |___example_case_coupled/
        |___WRF_FORCING/
        |___DOMAIN/
```

Compiling the code

This section will walk you through compiling the coupled WRF | WRF-Hydro modeling system and the WRF Preprocessing System (WPS) utilities

Compiling the coupled WRF | WRF-Hydro modeling system (note that this must be compiled prior to compiling the WPS)

1. Navigate to the WRF source code directory at WRF*
   ```
   cd WRF*
   ```
2. Remove the old WRF-Hydro source code contained within this directory and replace it with the updated version you just downloaded
   ```
   rm -r hydro
   cp -r ../wrf_hydro*/trunk/NDHMS hydro
   ```
3. Set environment variables for required dependencies (e.g. netCDF libraries - see the WRF documentation for specific requirements) and compile time options for the WRF-Hydro modeling system.
   Edit the provided template (WRF/hydro/template/setEnvar.sh) as desired, but be sure to set the variable WRF_HYDRO to 1 so that WRF compiles with hydro
   ```
   source WRF/hydro/template/setEnvar.sh
   ```
4. Configure the model compilation environment. For this walkthrough we will assume you are using the open source GNU compilers. If you are using different compilers, please select the appropriate option for your system.
   ```
   ./configure
   ```
   select options 34 (or as appropriate for your system) and 1 (for basic nesting)
5. Compile the code and pipe the output to a log file.
   ```
   ./compile em_real >& compile.log
   ```
   check the compile log for errors

Compiling the WRF Preprocessing System (WPS)

1. Navigate to the WPS source code directory at WPS*
2. Configure the model compilation environment. For this walkthrough we will assume you are using the open source GNU compilers. If you are using different compilers, please select the appropriate option for your system.
   ```
   ./configure
   ```
   select option 1 (or as appropriate for your system)
3. Compile the code and pipe the output to a log file.
   ```
   ./compile >& compile.log
   ```
   check the compile log for errors

Running the WRF Preprocessing System (WPS)

In this section we will use the compiled WRF Preprocessing System (WPS) utilities along with a namelist file (*namelist.wps*) and meteorological forcing data from the coupled test case to generate geogrid and metgrid files for the two model domains (note that the inner nest, or domain 2, is where WRF-Hydro will run).

Running the geogrid utility

The geogrid utility creates the geogrid domain file from data within the WPS*/geog folder based upon model domain parameters specified in the geogrid portion of the *namelist.wps* file and interpolation options specified in the *GEOGRID.TBL* distributed with WPS.

1. Create a run directory for WPS within your project directory
   ```
   mkdir -p run/WPS
   cd run/WPS
   ```
2. Now copy the required files for the WPS geogrid utility into your run directory
   ```
   cp ../../WPS*/geogrid.exe .
   cp ../../WPS*/GEOGRID.TBL .
   ln -sf ../../WPS*/geog .
   cp ../../example_case_coupled/namelist.wps .
   ```
   Edit the paths within this namelist as appropriate for your system
3. Next run the geogrid utility
   ```
   ./geogrid.exe >& geogrid.log
   ```

Running the ungrib utility

The ungrib utility takes meteorological forcing data to be used for simulation initial and boundary conditions and converts the files to an intermediate file format used by the metgrid utility.

1. Now copy the additional required files for the WPS ungrib utility into your run directory
   ```
   cp ../../WPS*/ungrib.exe .
   cp ../../WPS*/link_grib.csh .
   ```
2. Next copy over the necessary variable table for your forcing data
   ```
   cp ../../WPS*/ungrib/Variable_Tables/Vtable.NAM Vtable
   ```

3. Then link your forcing data from the test case to the run directory (this script will also rename the files to those expected for the ungrib utility)

```
./link_grib.csh ../../example_case_coupled/WRF_FORCING/*
```

4. Next run the ungrib utility

```
./ungrib.exe >& ungrib.log
```

Running the metgrid utility

The metgrid utility does some interpolation of meteorological forcing data to the model domain creating metgrid files to be used as input to the WRF real utility.

1. Now copy additional the required files for the WPS metgrid utility into your run directory

```
cp ../../WPS/metgrid.exe .
cp ../../WPS/METGRID.TBL .
```

2. Next run the metgrid utility

```
./metgrid.exe >& metgrid.log
```

Running a coupled WRF | WRF-Hydro simulation

In this section we will use our compiled coupled WRF | WRF-Hydro model to run a simulation. This walkthrough uses the Front Range coupled example test case. Details on the domain and time period of the simulation are provided in the example_case_coupled/README.txt file.

Setting up your run directory

First we will create a run directory and copy over or link the required files.

1. Create a run directory for WRF by copying over the run directory from where it was compiled

```
cp -RL WRF*/run WRF
```

2. Copy over parameter tables for WRF-Hydro from the template directory

```
cp ../../WRF/hydro/template/HYDRO/*TBL .
```

3. Copy over the namelists for real / wrf (namelist.input) and the hydro components (hydro.namelist) from the example case

```
cp ../../example_case_coupled/namelist.input .
cp ../../example_case_coupled/hydro.namelist .
```

4. Link the geogrid and metgrid files we just generated from the WPS utilities

```
ln -sf ../WPS/met_em* .
ln -sf ../WPS/geo_em* .
```

Running the real utility

The WRF real utility creates the wrfinput* and wrfbdy* initial and boundary condition files to be used as input for the coupled simulation.

1. Execute real.exe using the proper syntax for your system (example below) and pipe the output to a log file.

```
mpirun -np 2 ./real.exe >& real.log
```

2. Next review the rsl.out.* and rsl.error.* files for possible errors and check to make sure

the wrfinput* and wrfbdy* files have been created.

Running the coupled model

Now we will run the coupled model (all included in the wrf.exe binary) using the wrfinput* and wrfbdy* files as initial and boundary conditions and the model physics and other options selected in the namelist.input and hydro.namelist files.

1. Execute wrf.exe using the proper syntax for your system (example below) and pipe the output to a log file.

```
mpirun -np 2 ./wrf.exe >& wrf.log
```

2. If your simulation ran successfully, there should now be a large number of output files. Descriptions of the output files can be found in the *WRF-Hydro V5 Technical Description* at (https://ral.ucar.edu/projects/wrf_hydro) and the WRF User's Guide found here (http://www2.mmm.ucar.edu/wrf/users/docs/user_guide_v4/contents.html). You will also want to review the rsl.out.* and rsl.error.* files for possible error messages.